# Ink & Chemicals

Green printing is in every instance the story of printing as a whole. So far, we've seen that papermaking is an industry as much as it is an art, because it draws on a number of technologies, crafts and materials central to both modern and ancient civilization.

This is no less true for ink.

## Ink in the Ancient World

Simple inks were used as early as the 12th century BCE in China. Putting down a story or idea as a symbol for the sake of posterity, memory or communication is at the heart of what writing means in any civilization.

Different formulas for ink were developed independently in the ancient civilizations of China, India, the Middle East, Egypt and the Mediterranean. Early ink 'recipes' utilized a variety of natural materials: plant dyes, squid ink, iron and graphite-rich minerals mixed with water, among others. In South India, tar and soot from burned animal bones were used to compile sutras by ancient practitioners of the Jain religion that remain legible to this day. In Arabia, charcoal was used to create lampblack, which was popular centuries later in Europe.

Historically, the history of ink allowed writing to evolve at a much quicker pace as it diversified its

use and audience beyond the more laborious, limited method of stone and clay tablet etching and engraving. Long before a mechanical process for producing paper was developed, people were committing symbolic or phonetic writing systems like Sumerian cuneiform, Egyptian hieroglyphics or even the much later Latin-derived Roman alphabet to early forms of paper through ink.

Gall Nuts, Lithographs & Hot Metal Typesetting

Over the past 300 years, printing has mechanized writing as a standard that can be endlessly duplicated. The sky-rocket in demand for printed paper products had a likewise effect in the development of new industrial manufacture of inks for printing.

From the late 18th and 19th centuries to the present, new types of printing machines emerged at a regular rate to meet the growing role of printed materials in the working and leisure lives of people in the industrial world.

First developed in the High Middle Ages in Europe, ink made from "gall nuts", a tanno-gallate of iron compound, quickly became the most effective material for long-lasting documents. This formula worked so effectively, that it was still in use well into the 20th century.

Iron gall ink is composed of tannins found in oak trees and iron salts, producing a fluid ranging in color from light grey to a deep, purplish black. In conjunction with the tannic acid present in the oak wood, the ferric ions in the iron salts blacken when

exposed to oxygen.

By altering the measure of gallnut tannin to ferric sulfate, varying the amount of water used and adding other chemical substances such as gum arabic, hydrochloric acid and carbolic acid, inks for different environments and purposes were produced.

Iron gall was the principal ink used with the lithograph, introduced in 1796. This machine employed a limestone slab or metal plate coated with fats and wax to shape an image, as a pattern of hydrophobic and a hydrophilic surfaces, that directed where the water-based ink would absorb into the paper.

However, as wood fiber paper came to be an everyday reality in the West over the 19th and 20th centuries, the usefulness of iron gall ink declined. This was due to the difficulty with which the substance chemically bonds to cellulose, the principle cellular characteristic of the plant fibers in paper. Between the fast-growing demand by the market for paper and the industry designed to produce it, ink changed in character from what it had been for nearly 14,000 years.

In 1896, hot metal typesetting became popular in Britain and defined significantly how letterpress printing would work in the next century. By injecting molten metal into text-shaped cavities, an entire page (monotype) or a line of text (linotype) was made that would then be used to press the ink onto the paper.

The increasing dominance of metal-made printing

tools that the 1896 letterpress ushered in required a new ink formula that could work with metallic surfaces. Traditional iron gall ink dried too quickly on the metal type face, so an ink that retained liquid viscosity longer became the target for ink manufacture.

The answer was oil.  Oil could retain liquid viscosity.

## Oil & Ink

Oil-based ink became dominant from the end of the 19th century into the 20th. The concept of extracting oils from plants like flax, however, was not new; it is a method that dates back to 12th century France.

Ink is a lot like paint: dry pigment particles suspended in a fluid. When the fluid base evaporates, the particles "stick" to the surface of the paper. This fluid is called the "vehicle".

Purely aqueous inks like iron gall or India ink were enhanced from the 17th century on with the addition of oil-based varnishes. Adding varnish to pigments in place of water allowed a far more precise control over ink properties. Varnish was made by boiling an organic oil at a high temperature. The viscosity was determined by the type of oil used and the time it was allowed to 'cook'. Further modifiers like soap or resin were added to better control the characteristics of the varnish.

Oil-based inks became more popular on account of their durability and quick drying time. In addition, a number of different raw materials were used, ranging from vegetable oils to those extracted from the

fat of animals, such as whales. The most common source was linseed oil, which was taken from the dried seeds of the flax plant. Walnut and rapeseed were alternative sources.

Use of organic, largely agricultural resources began to shift to inorganic compounds from the late 19th century on, as industrial mining and oil extraction realized new materials were needed to create new pigments and varnish vehicles.

By the early 20th century, specific properties of printing ink were within the domain of manufacturing. New industrially-derived chemicals were used to manipulate more exactly the viscosity and drying time, which effects how the ink is absorbed into the paper. It was critical to avoid 'bleeding', which is when the ink goes beyond the target application area. The speed at which ink dries has a direct effect on the pace at which a printed page can be moved along in production without smearing.

Other inorganic materials were used throughout the last two hundred years to further influence the behavior of ink once it met paper. Minerals like cobalt and manganese were added to the oil-varnish solution to affect drying time. Today drier compounds are particularly important in multi-color printing since different color inks dry at different paces. Extenders are substances, usually inorganic solids, added to change the body of the ink and its acceptance onto the paper without affecting the appearance of the color.

The eventual dominance of petroleum and carbon-

based ink led to the development of toner in the 1950s and 1960s alongside the invention of the copy machine. The original photocopier toner was made of carbon sourced through coal. Eventually, as better refining technology emerged for the extraction of polymers from petroleum used for printing, toner would evolve into the inkjet cartridges used in today's home computer printer.

The elastic molecularity of inkjet toner produces a manageable drying time unlike ever before. First of all, it's dry. There's no need to apply a range of fluid additives to retain viscosity over a long period of time. Secondly, the molecules are incredibly sensitive to heat, of which the cartridge and laser mechanism take advantage to convert the powder momentarily into a liquid onto the paper.

This process involves a range of synthetic chemicals to help disperse and adhere the pigments within the polymer solution to the paper. Dispersing agents, or surfactants, form part of this chore and are traditionally made from substances like alkyl-sulfonates and ethoxylated alcohols.

However, there are drawbacks to all these apparent innovations.

Alkyl-sulfonates and ethoxylated alcohols, for instance, are toxic at certain levels. More generally, the mining and petroleum extraction on which these inks and chemicals rely carry with them a range of seriously detrimental changes to the local ecosystems that make up the global environmental picture.

## Green Ink

This brief survey of the evolution of ink alongside printing tells the same story we saw with paper production: the rise of industrial manufacture requires the use of raw materials that challenges the ecological stability of the planet. In the case of ink, the extraction of petroleum and coal through drilling and mining has a serious, negative impact on not only the environment, but on the health of those communities who depend on these industries financially.

So, what does the manufacture of green ink look like?

Sustainable ink production means that

- emissions and toxic waste are reduced;
- renewable resources are utilized throughout manufacture;
- any application of the ink can be removed or reused easily during the recycling of printing materials;
- and that no techniques, such as foil stamping, varnish finish or laminate, are used (these render materials unrecyclable).

## Soy Ink & Linseed Oil

Now an increasingly popular green alternative for printing companies and consumers alike, soy-based toner has a number of immediate benefits in terms of sustainability:

- Paper printed with soy-based ink can be re-

cycled easier.

- Soybeans are a renewable, organic resource with a lower impact on the environment than petroleum oil drilling and extraction.

- Soy ink has low levels of VOC (volatile organic compounds), which means less air pollution through fewer toxic emissions.

There are also a number of cost-effective benefits that come with using soy. Soy ink cartridges cost less than their traditional petroleum-based counterparts. Secondly, growing the variety of soybean (a non-food soy called "vinegar ink") is relatively inexpensive, needing low irrigation and little nutrition from the soil.

Soy ink first found success in the U.S. with newspapers. With such high print runs daily, newspaper firms were concerned about the instability of the fluctuating cost of ink tied to the global oil market. Papers began shifting to soy ink, a domestic agricultural product. By 2004, nearly all U.S. papers were printing with it.

A certified label is currently available on soy ink products promoted by the American Soybean Association, guaranteeing that a product has fulfilled the basic requirements of soy ink production designated by the organization.

Beyond soy, there has been a return to some of the original organic resources mentioned earlier, like linseed oil. Unlike producers in the 18th century, today's green ink manufacturers have the precision of

modern chemical technology to isolate from linseed oil the desired properties for a better ink. Better ink properties vary from viscosity and absorption to flow and drying time. Identifying and extracting bio-based polymers offers the practicality of traditional inks, with markedly reduced ecological implications.

## Sourcing Green Ink

Going green as a small business involves a number of choices.

By sourcing your printing needs from a company that deals only with certified, sustainably sourced paper and alternative inks with reduced environmental impact, you are already well on your way to closing two major channels of pollution, waste and ecological detriment in the world: foresting and oil drilling.

Green printers and presses choose to source the ink that they print with from manufacturers who are likewise committed to the principles of sustainability.

The next chapter will take this discussion further towards a better picture of what green printing looks like today, so that you know as a business what to look for when you choose to go green with your printing.

There are many chemicals used in the printing process. Obviously, ink is one of them, but it is not the only one. Chemicals are used in the plate-making process, in running and cleaning the printing press and in cleaning plates.

Alcohol mixed with water is used in the convention-

al lithographic printing process. The water involves Isopropyl Alcohol (IPA) or the substitute: the fountain solution. IPA is a VOC (Volatile Organic Compounds) and it is unhealthy to the operator and the environment. Fountain solution is composed of chemical additives that control the water's surface tension. However it produces water pollution when it is discharged as industrial waste water. Both IPA and the fountain solution are detrimental to the environment.

The "Chemical-free Dampening System" is the new printing process that does not use any agent with the dampening water. With this new chemical-free printing device, the water's surface tension is reduced without any additives. Only ordinary tap water is used as the dampening solution. This technology is new to the market and has not been instituted in the manufacture of printing presses thus far.

Things are changing so fast in the print industry that evolution sometimes seems to double up on itself. No sooner does one adaptation appear than another threatens to make it obsolete. The conventional image setter displaced typesetting equipment, plate setters replaced image setters and now chemical-free plate setters are replacing conventional plate setters. All this happened in less than 20 years. The capital cost of equipment in printing is amongst the highest in the manufacturing industry. Mostly, this is due to rapid changes in print technology. The important decisions of when and what equipment to buy are faced by printers every year. Green conscious customers can greatly affect this decision making, and lead printers to a green path.